Tropical Rainfall Measuring Mission
TRMM

Re-Engineering of the
TRMM Mission Control Center

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TRMM Overview
(Tropical Rainfall Measuring Mission)

- Mission overview
  - Launched on November 27, 1997
  - Mission designed to perform advanced monitoring of rainfall over the tropics/subtropics
  - 402 km orbit with 35 degree inclination
  - Instruments
    - Precipitation Radar (PR)
    - Visible and Infared Scanner (VIRS)
    - TRMM Microwave Imager (TMI)
    - Clouds and Earth's Radiant Energy System (CERES)
    - Lightning Imager Sensor (LIS)
  - Mission Design Lifetime is 3 years
  - All routine real-time supports conducted through TDRS (use of Omni or HGA)

MOC Re-engineering Objectives

- Objectives for Re-engineering the TRMM MOC
  - Reduce spacecraft and data operations costs by 50 percent in FY 2004 by introducing automation into the MOC
  - Delay HQ re-entry requirement by reducing unplanned sustaining engineering costs
    - Automate the ground support functions in the MOC which will enable staff reduction from 2 Console Engineers per shift to 1 in *January 2004*
    - Reduce hardware maintenance costs by replacing outdated ground system equipment by *November 2004*
  - Enable lights out operations for the midnight shift by *October 2004*
  - Demonstrate the GMSEC architecture as a proof of concept to use as the basis for automating other EOS missions (Terra, Aqua, Aura) and GPM

Overall Technical Approach

- Utilize a rapid prototyping development methodology
- Institute a phased approach to meet TRMM Project's immediate budgetary concerns from HQ
- Implement auto-notification system to enable initial reduction in staff
  - Alert Notification System Router (ANSR)
- Replace TPOCC T&C system and Front End Processor
  - Eclipse ground system
  - IRTS (IPTX Real Time System)
- Replace PTP/SCDs hardware and switches with software based IRTS front end (TFE)
- Integrate ground components into GMSEC middleware architecture
  - MOPSS, AutoFDS, Eclipse, IRTS (renamed TFE - TRMM Front End)
- Automate routine pass activities
- Provide simple ground automation (e.g. string failovers)

Automation Approach

- Automate spacecraft real-time activities during night shift

- Configure ground system pre-pass, in-pass monitoring, and post-pass

- Notify offline engineering staff in the event of an unexpected ground and spacecraft event

- Respond to selected ground system anomalies to perform re-configurations when required
  - Respond based on ground event message
  - Respond based on failure of "heartbeat" message

GMSEC System Architecture
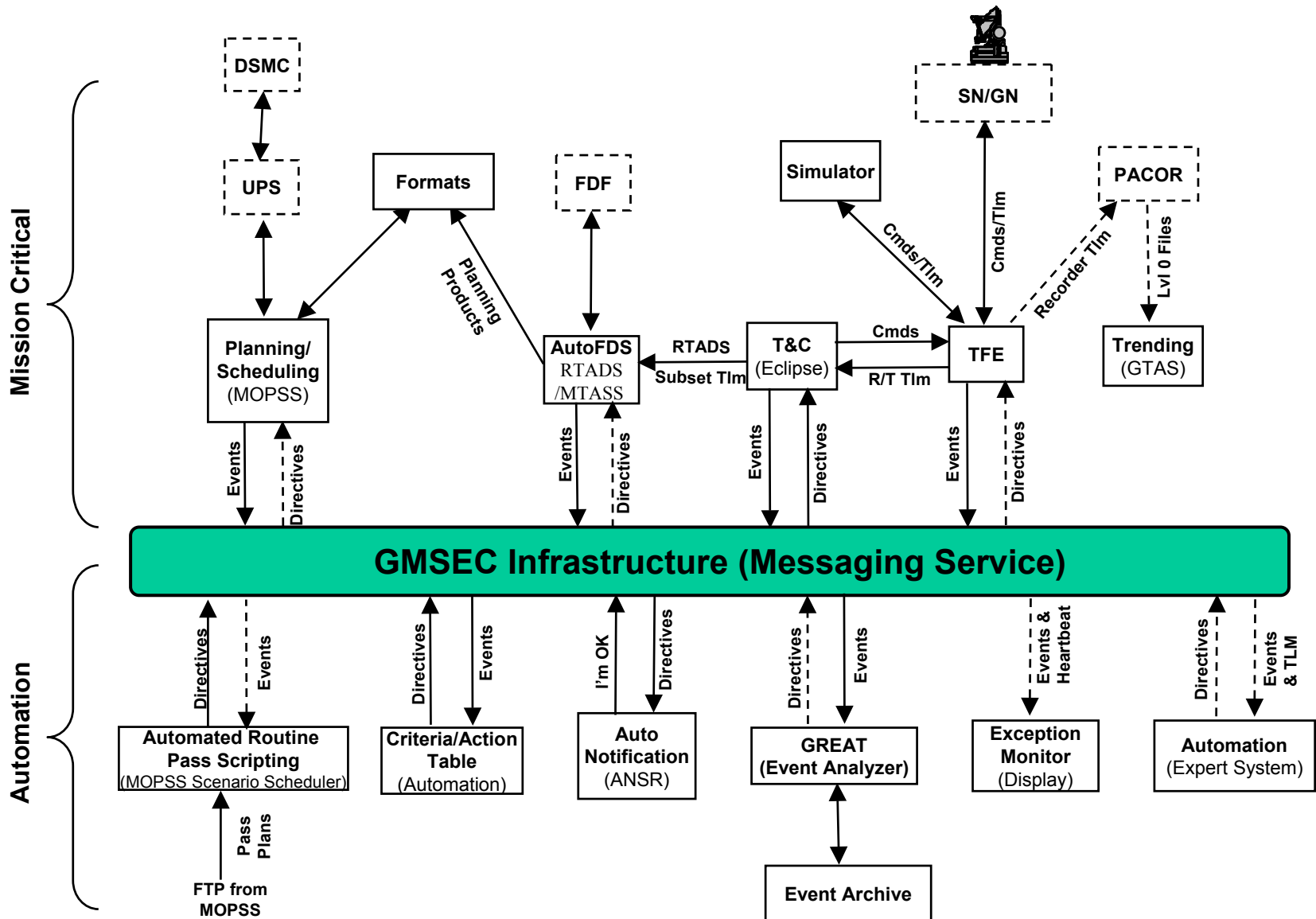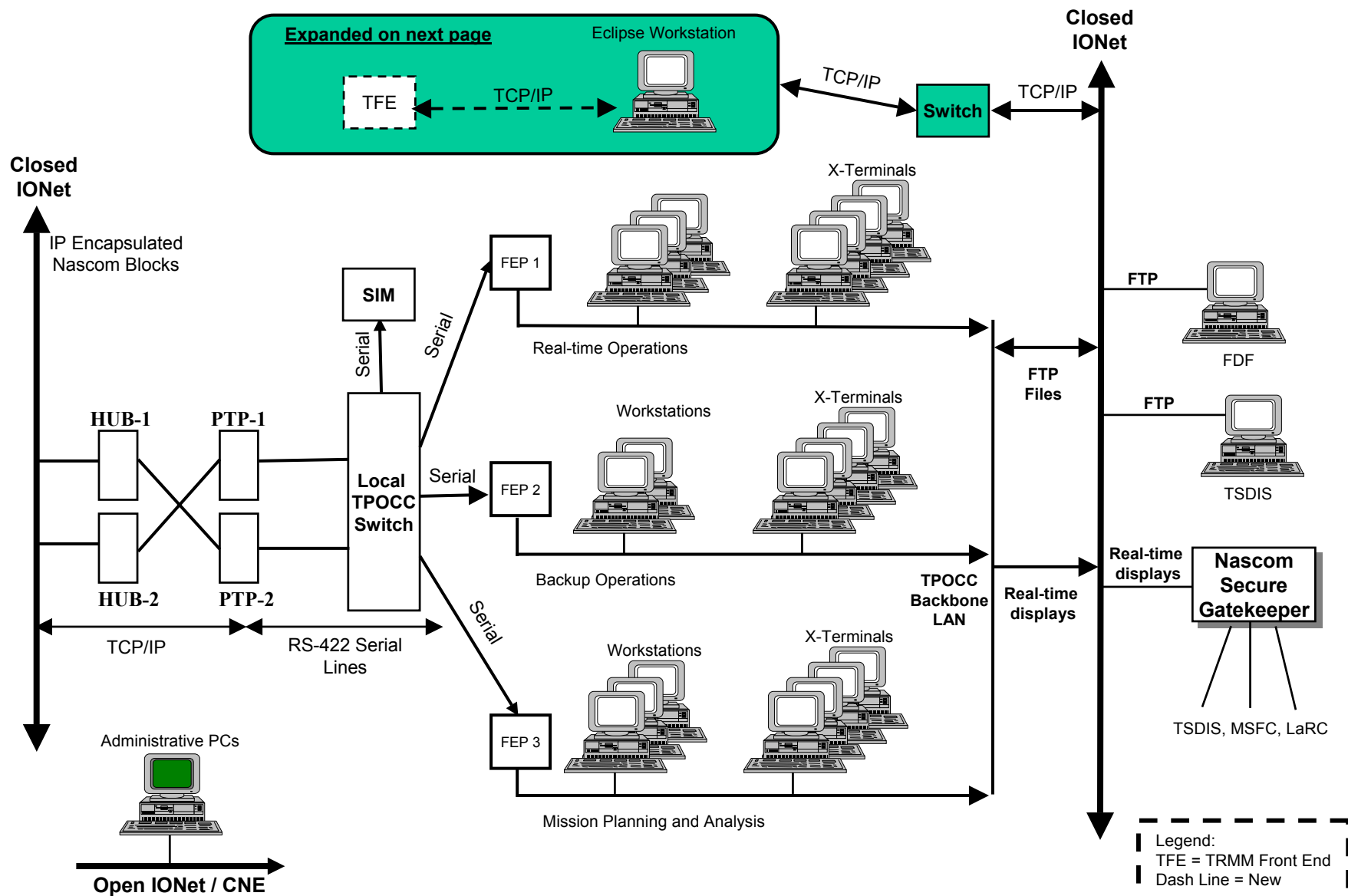
ANSR Implementation

- **Integrate ANSR auto-notification system with existing T&C system (TPOCC)**
  - Enables initial reduction in staff by providing a backup to on-shift console detection of unexpected spacecraft and ground events
  - Currently operational in the MOC with Phase 1 functionality
  - Phase 1 ORR held 1/15/04
  - Phase 2 final build delivered 7/30/04
- **ANSR Phase 1 capabilities:**
  - Provides one-way text paging services via paging service provider and email (via NASA CNE)
  - Analyzes TPOCC events and alerts FOT offline engineers based on FOT developed and maintained rule set
- **ANSR Phase 2 capabilities:**
  - ANSR implemented in GMSEC environment to support midnight shift lights out operations
  - Provide two-way paging services to allow acknowledgement of pages by off-line FOT
  - Provides redundancy and increased robustness to ensure continuous operations
  - Responds to directives from the GMSEC automation software (Criteria Action Table)

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Phase 1
Mission Critical Systems

- Mission critical prototype systems to be delivered and tested in Bldg 32 MOC

- Phase 1 SDR held 2/2/04 for mission critical systems

- *Eclipse Integration*
  - Prototype Eclipse server/workstation delivered to MOC 3/31/04
  - Full build Eclipse supporting three operational strings delivered 7/1/04
  - **Benefits include***:
    - Provides ESMO with the same T&C system for all missions
    - Replaces current HP platform workstations with lower cost Windows platform

- *TRMM Front End Integration*
  - Prototype TFE Sun Blade ready for delivery in MOC when network connectivity is in place – includes telemetry flow only
  - Final operational build to support integration with Eclipse delivered 3/19/04
  - **Benefits include***:
    - Replaces PTP/SCD and local TPOCC hardware switch to reduce manual configuration
    - Provides capability to configure interface to NASCOM via software
    - Conversion from Serial to IP protocol eliminates the need for SCD H/W

Development MOC Configuration Diagram (Building 32)

Expanded on next page

Eclipse Workstation

TFE ←--- TCP/IP ---→

Closed IONet

TCP/IP

TCP/IP

Switch

Closed IONet

IP Encapsulated Nascom Blocks

SIM

FEP 1

X-Terminals

Real-time Operations

FTP

FDF

HUB-1   PTP-1

HUB-2   PTP-2

Local TPOCC Switch

Serial

Serial

Serial

Serial

FEP 2

Workstations   X-Terminals

Backup Operations

FTP Files

FTP

TSDIS

TCP/IP

RS-422 Serial Lines

FEP 3

Workstations   X-Terminals

Mission Planning and Analysis

TPOCC Backbone LAN

Real-time displays

Real-time displays

Nascom Secure Gatekeeper

TSDIS, MSFC, LaRC

Administrative PCs

Open IONet / CNE

Legend:
TFE = TRMM Front End
Dash Line = New
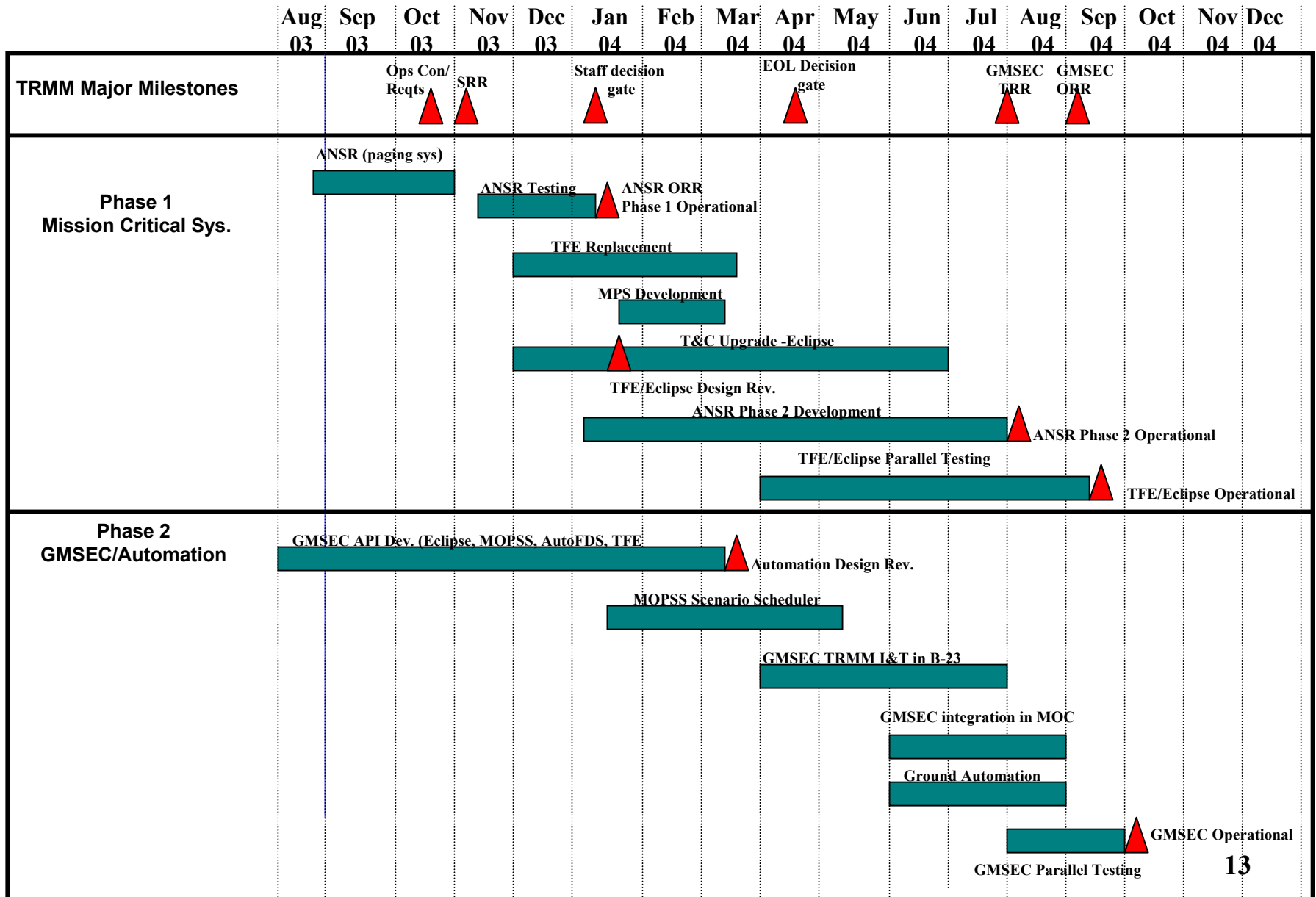
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Phase 2
GMSEC Architecture/Automation

- **GMSEC prototype systems to be tested in Bldg 23 GMSEC Lab prior to integration into MOC**
- **Phase 2 SDR for GMSEC Automation Systems – late March**
- **GMSEC Implementation Approach:**
  - *GMSEC Middleware Software Bus*
    - TIBCO Smart Sockets - offers guaranteed delivery of event messages and directives
    - MOC components will make software modifications to support GMSEC message formats and API for communication on the bus
    - Initial implementation will support event messages, directives, and heartbeat messages only
      - Telemetry and MOC products will not be transferred via the bus
    - Installation of middleware and MOC components in GMSEC Lab beginning 4/1/04 for testing
    - Integration in MOC beginning 7/1/04
  - **Benefits include:**
    - Facilitates automation and offers access to information from all MOC components
    - Enables "plug and play" COTS as MOC systems evolve
    - Provides integrated ground message system

Phase 2
GMSEC Architecture/Automation cont'd

- **Automation Approach:**
  - *MOPSS Scenario Scheduler*
    - Implemented to automate routine time ordered activities
      - Perform MOC configuration functions (pre-pass, realtime support, and breakdown) at pre-specified times
      - Prototype build delivered 3/31/04
      - Final operational build delivered 4/30/04
  - *Criteria Action Table (CAT) Automation Tool*
    - Implemented to perform criteria based automatic responses to ground generated event messages
    - Sends auto-notification directive to ANSR paging system for text paging FOT when spacecraft limits violated and critical ground events occur
    - Sends directive to trigger automatic ground reconfigurations for most common ground anomalies (TFE or Eclipse workstation failovers)
      - Prototype build delivered 3/31/04
      - Final operational build delivered 5/31/04
  - *Benefits include:*
    - Simple automation tools will be easily maintainable by existing FOT staff
    - Reusable automation techniques will be directly transferrable to other EOS missions

TRMM Re-Engineering Schedule

	Aug 03	Sep 03	Oct 03	Nov 03	Dec 03	Jan 04	Feb 04	Mar 04	Apr 04	May 04	Jun 04	Jul 04	Aug 04	Sep 04	Oct 04	Nov 04	Dec 04

TRMM Major Milestones
- Ops Con/Reqts ▲
- SRR ▲
- Staff decision gate ▲
- EOL Decision gate ▲
- GMSEC TRR ▲
- GMSEC ORR ▲

Phase 1 Mission Critical Sys.
- ANSR (paging sys)
- ANSR Testing
- ANSR ORR ▲ Phase 1 Operational
- TFE Replacement
- MPS Development
- T&C Upgrade -Eclipse
- ▲ TFE/Eclipse Design Rev.
- ANSR Phase 2 Development
- ▲ ANSR Phase 2 Operational
- TFE/Eclipse Parallel Testing
- ▲ TFE/Eclipse Operational

Phase 2 GMSEC/Automation
- GMSEC API Dev. (Eclipse, MOPSS, AutoFDS, TFE
- ▲ Automation Design Rev.
- MOPSS Scenario Scheduler
- GMSEC TRMM I&T in B-23
- GMSEC integration in MOC
- Ground Automation
- ▲ GMSEC Operational
- GMSEC Parallel Testing

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TRMM Re-Engineering Top Risks

Rank	Risk Statement	Approach & Plan
1 High	Meeting aggressive schedule within budget cost -MOMS contract transition delays and unexpected overhead costs -Delay in Raytheon contract startup due to ESMO cost issues -H/W procurement delayed due to ESMO budget issues	Mitigation: 1) ESMO funded prototype to initiate work while overall cost negotiation continues 2) Borrowed H/W for prototyping effort
2 High	Too many changes to existing system may cause system level problems ➤Auto-notification system ➤T&C system replacement ➤ Front end processor ➤ GMSEC integration	Mitigation: 1) Incremental changes to existing system phased in over FY04 ➤ Auto-notification first ➤ Eclipse & front end next ➤ GMSEC integration ➤ Automation 2) Isolating mission critical elements from automation elements 3) Rapid prototyping methodology to expedite FOT parallel testing
3 Med	Uncertainties in GMSEC may cause schedule to slip and cost to increase. GMSEC has not been used operationally. GMSEC automation tool is in development now.	Mitigation: 1) Initially isolate T&C string from GMSEC bus to ensure mission critical functions not affected 2) Keep automation requirements to a minimum by concentrating on event message and directives only
4 Med	FOT and high fidelity simulator resource contention due to EOL planning activities	Mitigation: 1) ESMO agreed to provide a dedicated TRMM Off-Line Engineer 2) Multi-Purpose Simulator (MPS) will be used for majority of the testing

TFE 1

DLT

RAID

ECLIPSE SERVER (P)

TFE 2

RAID

ECLIPSE SERVER (B)

TFE 3

ECLIPSE R/T (P)

ECLIPSE R/T (P)

ECLIPSE R/T (P)

TSDIS

Eclipse/TFE Subnets

ECLIPSE R/T (B)

ECLIPSE R/T (B)

Archive Raid 1 or 5

WSC/ DSMC

TCP /IP

UPS

FTP

FDF

FTP

FSW LAB

FTp Cmd / TLM

CLOSED I/O NET

R/T

R/T

MOPSS Server & Scenario Scheduler (P)

1. Criteria Action Table
2. Paging Marshall
3. GMSEC MOPSS API (P)

GREAT (P)

AutoFDS

R/T

R/T

GMSEC SERVER (P)

GMSEC SERVER (B)

GMSEC Subnets

Archive Raid 1 or 5

R/T

R/T

Scenario Scheduler (B)

1. Criteria Action Table
2. Paging Marshall
3. GMSEC MOPSS API (B)

GREAT (B)

UPS (new?)

FORMATS (new?)

TPOCC FE 1

AutoFDS (P)

Tr2ws1 offl evt TRMM MP FORMATS (B) ANSR evtsrv

Tr2xt1 R/T

Tr2ws2 MOPSS Oracle (B)

Tr2xt2 UPS display (B)

Tr2ws3 GTAS

tr2lj1

TR32-10A

TPOCC Subnets

TPOCC FE 2

Tr3ws1 offl evt TRMM MP FORMATS (P)

Tr3ws2 MOPSS Oracle (P)

Tr3xt2 UPS display (P)

Tr3ost FSW PC

Tr3ws3 R/T

tr3xt3 R/T

tr3lj1

TR32-10B

CNE

Administrative PC email Internet Acc.

TRMM Web Server & LZP

AutoFDSO Product Server (B)

ANSR PC

P - Prime
B - Backup